$LT_{tm}[z(j),z(i)] = X_{tm}[z(j)] + av_{tm}[z(j)] + vf[z(j),z(i)]$ dB
$LT_{nm}[z(j),z(i)] = X_{nm}[z(j)] + av_{nm}[z(j)] + vf[z(j),z(i)]$ dB

In this formula, LT_{tm} and LT_{nm} are the individual masking thresholds at critical band rate z in Bark of the masking component at the critical band rate of the masker z_m in Bark. The values in dB can be either positive or negative. The term $X_{tm}[z(j)]$ is the sound pressure level of the masking component with the index number j at the corresponding critical band rate z(j). The term av is called the masking index and vf the masking function of the masking component $X_{tm}[z(j)]$. The masking index av is different for tonal and non-tonal maskers (av_{tm} and av_{nm}).

For tonal maskers it is given by

$av_{tm} = -1{,}525 - 0{,}275 * z(j) - 4{,}5$ dB,

and for non-tonal maskers

$av_{nm} = -1{,}525 - 0{,}175 * z(j) - 0{,}5$ dB.

The masking function vf of a masker is characterized by different lower and upper slopes, which depend on the distance in Bark dz = z(i)- z(j) to the masker. In this expression i is the index of the spectral line at which the masking function is calculated and j that of the masker. The critical band rates z(j) and z(i) can be found in tables D.1a, D.1b, D.1c for Layer I; tables D.1d, D.1e, D.1f for Layer II. The masking function, which is the same for tonal and non-tonal maskers, is given by:

$vf = 17 * (dz + 1) - (0{,}4 * X[z(j)] + 6)$ dB	for $-3 <= dz < -1$ Bark
$vf = (0{,}4 * X[z(j)] + 6) * dz$ dB	for $-1 <= dz < 0$ Bark
$vf = -17 * dz$ dB	for $0 <= dz < 1$ Bark
$vf = -(dz - 1) * (17 - 0{,}15 * X[z(j)]) - 17$ dB	for $1 <= dz < 8$ Bark

In these expressions X[z(j)] is the sound pressure level of the j'th masking component in dB. For reasons of implementation complexity, the masking is no longer considered (LT_{tm} and LT_{nm} are set to -∞ dB outside this range) if dz < -3 Bark, or dz >= 8 Bark.

Step 7: Calculation of the global masking threshold LT_g

The global masking threshold $LT_g(i)$ at the i'th frequency sample is derived from the upper and lower slopes of the individual masking thresholds of each of the j tonal and non-tonal maskers and from the threshold in quiet $LT_q(i)$. This is also given in tables D.1a, D.1b, D.1c for Layer I; tables D.1d, D.1e, D.1f for Layer II. The global masking threshold is found by summing the powers corresponding to the individual masking thresholds and the threshold in quiet.

$$LT_g(i) = 10 \log_{10} \left(10^{LT_q(i)/10} + \sum_{j=1}^{m} 10^{LT_{tm}(z(j),z(i))/10} + \sum_{j=1}^{n} 10^{LT_{nm}(z(j),z(i))/10} \right)$$

The total number of tonal maskers is given by m, and the total number of non-tonal maskers is given by n. For a given i, the range of j can be reduced to just encompass those masking components that are within -8 to +3 Bark from i. Outside of this range LT_{tm} and LT_{nm} are -∞ dB.

Step 8: Determination of the minimum masking threshold

The minimum masking level LTmin(n) in subband n is determined by the following expression:

$$LT_{min}(n) = \underset{f(i) \text{ in subband } n}{\mathrm{MIN}}[\, LT_g(i)\,] \text{ dB}$$

where f(i) is the frequency of the i'th frequency sample. The f(i) are tabulated in tables D.1a, D.1b, D.1c for Layer I; tables D.1d, D.1e, D.1f for Layer II. A minimum masking level $LT_{min}(n)$ is computed for every subband.

Step 9: Calculation of the signal-to-mask-ratio

The signal-to-mask ratio

$$SMR_{sb}(n) = L_{sb}(n) - LT_{min}(n) \quad \text{dB}$$

is computed for every subband n.

**Table D.1a. -- Frequencies, critical band rates and absolute threshold
Table is valid for Layer I at a sampling rate of 32 kHz.**

Index Number i	Frequency [Hz]	Crit.Band Rate [z]	Absolute Thresh. [dB]
1	62,50	0,617	33,44
2	125,00	1,232	19,20
3	187,50	1,842	13,87
4	250,00	2,445	11,01
5	312,50	3,037	9,20
6	375,00	3,618	7,94
7	437,50	4,185	7,00
8	500,00	4,736	6,28
9	562,50	5,272	5,70
10	625,00	5,789	5,21
11	687,50	6,289	4,80
12	750,00	6,770	4,45
13	812,50	7,233	4,14
14	875,00	7,677	3,86
15	937,50	8,103	3,61
16	1 000,00	8,511	3,37
17	1 062,50	8,901	3,15
18	1 125,00	9,275	2,93
19	1 187,50	9,632	2,73
20	1 250,00	9,974	2,53
21	1 312,50	10,301	2,32
22	1 375,00	10,614	2,12
23	1 437,50	10,913	1,92
24	1 500,00	11,199	1,71
25	1 562,50	11,474	1,49
26	1 625,00	11,736	1,27
27	1 687,50	11,988	1,04
28	1 750,00	12,230	0,80
29	1 812,50	12,461	0,55
30	1 875,00	12,684	0,29
31	1 937,50	12,898	0,02
32	2 000,00	13,104	-0,25
33	2 062,50	13,302	-0,54
34	2 125,00	13,493	-0,83
35	2 187,50	13,678	-1,12
36	2 250,00	13,855	-1,43
37	2 312,50	14,027	-1,73
38	2 375,00	14,193	-2,04
39	2 437,50	14,354	-2,34
40	2 500,00	14,509	-2,64
41	2 562,50	14,660	-2,93
42	2 625,00	14,807	-3,22
43	2 687,50	14,949	-3,49
44	2 750,00	15,087	-3,74
45	2 812,50	15,221	-3,98
46	2 875,00	15,351	-4,20
47	2 937,50	15,478	-4,40
48	3 000,00	15,602	-4,57
49	3 125,00	15,841	-4,82
50	3 250,00	16,069	-4,96
51	3 375,00	16,287	-4,97
52	3 500,00	16,496	-4,86
53	3 625,00	16,697	-4,63
54	3 750,00	16,891	-4,29
55	3 875,00	17,078	-3,87
56	4 000,00	17,259	-3,39
57	4 125,00	17,434	-2,86
58	4 250,00	17,605	-2,31
59	4 375,00	17,770	-1,77
60	4 500,00	17,932	-1,24
61	4 625,00	18,089	-0,74
62	4 750,00	18,242	-0,29
63	4 875,00	18,392	0,12
64	5 000,00	18,539	0,48
65	5 125,00	18,682	0,79
66	5 250,00	18,823	1,06
67	5 375,00	18,960	1,29
68	5 500,00	19,095	1,49
69	5 625,00	19,226	1,66
70	5 750,00	19,356	1,81
71	5 875,00	19,482	1,95
72	6 000,00	19,606	2,08
73	6 250,00	19,847	2,33
74	6 500,00	20,079	2,59
75	6 750,00	20,300	2,86
76	7 000,00	20,513	3,17
77	7 250,00	20,717	3,51
78	7 500,00	20,912	3,89
79	7 750,00	21,098	4,31
80	8 000,00	21,275	4,79
81	8 250,00	21,445	5,31
82	8 500,00	21,606	5,88
83	8 750,00	21,760	6,50
84	9 000,00	21,906	7,19
85	9 250,00	22,046	7,93
86	9 500,00	22,178	8,75
87	9 750,00	22,304	9,63
88	10 000,00	22,424	10,58
89	10 250,00	22,538	11,60
90	10 500,00	22,646	12,71
91	10 750,00	22,749	13,90
92	11 000,00	22,847	15,18
93	11 250,00	22,941	16,54
94	11 500,00	23,030	18,01
95	11 750,00	23,114	19,57
96	12 000,00	23,195	21,23
97	12 250,00	23,272	23,01
98	12 500,00	23,345	24,90
99	12 750,00	23,415	26,90
100	13 000,00	23,482	29,03
101	13 250,00	23,546	31,28
102	13 500,00	23,607	33,67
103	13 750,00	23,666	36,19
104	14 000,00	23,722	38,86
105	14 250,00	23,775	41,67
106	14 500,00	23,827	44,63
107	14 750,00	23,876	47,76
108	15 000,00	23,923	51,04

Table D.1b. -- Frequencies, critical band rates and absolute threshold
Table is valid for Layer I at a sampling rate of 44,1 kHz.

Index Number i	Frequency [Hz]	Crit.Band Rate [z]	Absolute Thresh. [dB]
1	86,13	0,850	25,87
2	172,27	1,694	14,85
3	258,40	2,525	10,72
4	344,53	3,337	8,50
5	430,66	4,124	7,10
6	516,80	4,882	6,11
7	602,93	5,608	5,37
8	689,06	6,301	4,79
9	775,20	6,959	4,32
10	861,33	7,581	3,92
11	947,46	8,169	3,57
12	1 033,59	8,723	3,25
13	1 119,73	9,244	2,95
14	1 205,86	9,734	2,67
15	1 291,99	10,195	2,39
16	1 378,13	10,629	2,11
17	1 464,26	11,037	1,83
18	1 550,39	11,421	1,53
19	1 636,52	11,783	1,23
20	1 722,66	12,125	0,90
21	1 808,79	12,448	0,56
22	1 894,92	12,753	0,21
23	1 981,05	13,042	-0,17
24	2 067,19	13,317	-0,56
25	2 153,32	13,578	-0,96
26	2 239,45	13,826	-1,38
27	2 325,59	14,062	-1,79
28	2 411,72	14,288	-2,21
29	2 497,85	14,504	-2,63
30	2 583,98	14,711	-3,03
31	2 670,12	14,909	-3,41
32	2 756,25	15,100	-3,77
33	2 842,38	15,284	-4,09
34	2 928,52	15,460	-4,37
35	3 014,65	15,631	-4,60
36	3 100,78	15,796	-4,78
37	3 186,91	15,955	-4,91
38	3 273,05	16,110	-4,97
39	3 359,18	16,260	-4,98
40	3 445,31	16,406	-4,92
41	3 531,45	16,547	-4,81
42	3 617,58	16,685	-4,65
43	3 703,71	16,820	-4,43
44	3 789,84	16,951	-4,17
45	3 875,98	17,079	-3,87
46	3 962,11	17,205	-3,54
47	4 048,24	17,327	-3,19
48	4 134,38	17,447	-2,82
49	4 306,64	17,680	-2,06
50	4 478,91	17,905	-1,32
51	4 651,17	18,121	-0,64
52	4 823,44	18,331	-0,04
53	4 995,70	18,534	0,47
54	5 167,97	18,731	0,89
55	5 340,23	18,922	1,23
56	5 512,50	19,108	1,51
57	5 684,77	19,289	1,74
58	5 857,03	19,464	1,93
59	6 029,30	19,635	2,11
60	6 201,56	19,801	2,28
61	6 373,83	19,963	2,46
62	6 546,09	20,120	2,63
63	6 718,36	20,273	2,82
64	6 890,63	20,421	3,03
65	7 062,89	20,565	3,25
66	7 235,16	20,705	3,49
67	7 407,42	20,840	3,74
68	7 579,69	20,972	4,02
69	7 751,95	21,099	4,32
70	7 924,22	21,222	4,64
71	8 096,48	21,342	4,98
72	8 268,75	21,457	5,35
73	8 613,28	21,677	6,15
74	8 957,81	21,882	7,07
75	9 302,34	22,074	8,10
76	9 646,88	22,253	9,25
77	9 991,41	22,420	10,54
78	10 335,94	22,576	11,97
79	10 680,47	22,721	13,56
80	11 025,00	22,857	15,31
81	11 369,53	22,984	17,23
82	11 714,06	23,102	19,34
83	12 058,59	23,213	21,64
84	12 403,13	23,317	24,15
85	12 747,66	23,415	26,88
86	13 092,19	23,506	29,84
87	13 436,72	23,592	33,05
88	13 781,25	23,673	36,52
89	14 125,78	23,749	40,25
90	14 470,31	23,821	44,27
91	14 814,84	23,888	48,59
92	15 159,38	23,952	53,22
93	15 503,91	24,013	58,18
94	15 848,44	24,070	63,49
95	16 192,97	24,125	68,00
96	16 537,50	24,176	68,00
97	16 882,03	24,225	68,00
98	17 226,56	24,271	68,00
99	17 571,09	24,316	68,00
100	17 915,63	24,358	68,00
101	18 260,16	24,398	68,00
102	18 604,69	24,436	68,00
103	18 949,22	24,473	68,00
104	19 293,75	24,508	68,00
105	19 638,28	24,542	68,00
106	19 982,81	24,574	68,00

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Table D.1c. -- Frequencies, critical band rates and absolute threshold
Table is valid for Layer I at a sampling rate of 48 kHz.

Index Number i	Frequency [Hz]	Crit.Band Rate [z]	Absolute Thresh. [dB]
1	93,75	0,925	24,17
2	187,50	1,842	13,87
3	281,25	2,742	10,01
4	375,00	3,618	7,94
5	468,75	4,463	6,62
6	562,50	5,272	5,70
7	656,25	6,041	5,00
8	750,00	6,770	4,45
9	843,75	7,457	4,00
10	937,50	8,103	3,61
11	1 031,25	8,708	3,26
12	1 125,00	9,275	2,93
13	1 218,75	9,805	2,63
14	1 312,50	10,301	2,32
15	1 406,25	10,765	2,02
16	1 500,00	11,199	1,71
17	1 593,75	11,606	1,38
18	1 687,50	11,988	1,04
19	1 781,25	12,347	0,67
20	1 875,00	12,684	0,29
21	1 968,75	13,002	-0,11
22	2 062,50	13,302	-0,54
23	2 156,25	13,586	-0,97
24	2 250,00	13,855	-1,43
25	2 343,75	14,111	-1,88
26	2 437,50	14,354	-2,34
27	2 531,25	14,585	-2,79
28	2 625,00	14,807	-3,22
29	2 718,75	15,018	-3,62
30	2 812,50	15,221	-3,98
31	2 906,25	15,415	-4,30
32	3 000,00	15,602	-4,57
33	3 093,75	15,783	-4,77
34	3 187,50	15,956	-4,91
35	3 281,25	16,124	-4,98
36	3 375,00	16,287	-4,97
37	3 468,75	16,445	-4,90
38	3 562,50	16,598	-4,76
39	3 656,25	16,746	-4,55
40	3 750,00	16,891	-4,29
41	3 843,75	17,032	-3,99
42	3 937,50	17,169	-3,64
43	4 031,25	17,303	-3,26
44	4 125,00	17,434	-2,86
45	4 218,75	17,563	-2,45
46	4 312,50	17,688	-2,04
47	4 406,25	17,811	-1,63
48	4 500,00	17,932	-1,24
49	4 687,50	18,166	-0,51
50	4 875,00	18,392	0,12
51	5 062,50	18,611	0,64
52	5 250,00	18,823	1,06
53	5 437,50	19,028	1,39
54	5 625,00	19,226	1,66
55	5 812,50	19,419	1,88
56	6 000,00	19,606	2,08
57	6 187,50	19,788	2,27
58	6 375,00	19,964	2,46
59	6 562,50	20,135	2,65
60	6 750,00	20,300	2,86
61	6 937,50	20,461	3,09
62	7 125,00	20,616	3,33
63	7 312,50	20,766	3,60
64	7 500,00	20,912	3,89
65	7 687,50	21,052	4,20
66	7 875,00	21,188	4,54
67	8 062,50	21,318	4,91
68	8 250,00	21,445	5,31
69	8 437,50	21,567	5,73
70	8 625,00	21,684	6,18
71	8 812,50	21,797	6,67
72	9 000,00	21,906	7,19
73	9 375,00	22,113	8,33
74	9 750,00	22,304	9,63
75	10 125,00	22,482	11,08
76	10 500,00	22,646	12,71
77	10 875,00	22,799	14,53
78	11 250,00	22,941	16,54
79	11 625,00	23,072	18,77
80	12 000,00	23,195	21,23
81	12 375,00	23,309	23,94
82	12 750,00	23,415	26,90
83	13 125,00	23,515	30,14
84	13 500,00	23,607	33,67
85	13 875,00	23,694	37,51
86	14 250,00	23,775	41,67
87	14 625,00	23,852	46,17
88	15 000,00	23,923	51,04
89	15 375,00	23,991	56,29
90	15 750,00	24,054	61,94
91	16 125,00	24,114	68,00
92	16 500,00	24,171	68,00
93	16 875,00	24,224	68,00
94	17 250,00	24,275	68,00
95	17 625,00	24,322	68,00
96	18 000,00	24,368	68,00
97	18 375,00	24,411	68,00
98	18 750,00	24,452	68,00
99	19 125,00	24,491	68,00
100	19 500,00	24,528	68,00
101	19 875,00	24,564	68,00
102	20 250,00	24,597	68,00

Table D.1d. -- Frequencies, critical band rates and absolute threshold
Table is valid for Layer II at a sampling rate of 32 kHz.

Index Number i	Frequency [Hz]	Crit.Band Rate [z]	Absolute Thresh. [dB]
1	31,25	0,309	58,23
2	62,50	0,617	33,44
3	93,75	0,925	24,17
4	125,00	1,232	19,20
5	156,25	1,538	16,05
6	187,50	1,842	13,87
7	218,75	2,145	12,26
8	250,00	2,445	11,01
9	281,25	2,742	10,01
10	312,50	3,037	9,20
11	343,75	3,329	8,52
12	375,00	3,618	7,94
13	406,25	3,903	7,44
14	437,50	4,185	7,00
15	468,75	4,463	6,62
16	500,00	4,736	6,28
17	531,25	5,006	5,97
18	562,50	5,272	5,70
19	593,75	5,533	5,44
20	625,00	5,789	5,21
21	656,25	6,041	5,00
22	687,50	6,289	4,80
23	718,75	6,532	4,62
24	750,00	6,770	4,45
25	781,25	7,004	4,29
26	812,50	7,233	4,14
27	843,75	7,457	4,00
28	875,00	7,677	3,86
29	906,25	7,892	3,73
30	937,50	8,103	3,61
31	968,75	8,309	3,49
32	1 000,00	8,511	3,37
33	1 031,25	8,708	3,26
34	1 062,50	8,901	3,15
35	1 093,75	9,090	3,04
36	1 125,00	9,275	2,93
37	1 156,25	9,456	2,83
38	1 187,50	9,632	2,73
39	1 218,75	9,805	2,63
40	1 250,00	9,974	2,53
41	1 281,25	10,139	2,42
42	1 312,50	10,301	2,32
43	1 343,75	10,459	2,22
44	1 375,00	10,614	2,12
45	1 406,25	10,765	2,02
46	1 437,50	10,913	1,92
47	1 468,75	11,058	1,81
48	1 500,00	11,199	1,71
49	1 562,50	11,474	1,49
50	1 625,00	11,736	1,27
51	1 687,50	11,988	1,04
52	1 750,00	12,230	0,80
53	1 812,50	12,461	0,55
54	1 875,00	12,684	0,29
55	1 937,50	12,898	0,02
56	2 000,00	13,104	-0,25
57	2 062,50	13,302	-0,54
58	2 125,00	13,493	-0,83
59	2 187,50	13,678	-1,12
60	2 250,00	13,855	-1,43
61	2 312,50	14,027	-1,73
62	2 375,00	14,193	-2,04
63	2 437,50	14,354	-2,34
64	2 500,00	14,509	-2,64
65	2 562,50	14,660	-2,93
66	2 625,00	14,807	-3,22
67	2 687,50	14,949	-3,49
68	2 750,00	15,087	-3,74
69	2 812,50	15,221	-3,98
70	2 875,00	15,351	-4,20
71	2 937,50	15,478	-4,40
72	3 000,00	15,602	-4,57
73	3 125,00	15,841	-4,82
74	3 250,00	16,069	-4,96
75	3 375,00	16,287	-4,97
76	3 500,00	16,496	-4,86
77	3 625,00	16,697	-4,63
78	3 750,00	16,891	-4,29
79	3 875,00	17,078	-3,87
80	4 000,00	17,259	-3,39
81	4 125,00	17,434	-2,86
82	4 250,00	17,605	-2,31
83	4 375,00	17,770	-1,77
84	4 500,00	17,932	-1,24
85	4 625,00	18,089	-0,74
86	4 750,00	18,242	-0,29
87	4 875,00	18,392	0,12
88	5 000,00	18,539	0,48
89	5 125,00	18,682	0,79
90	5 250,00	18,823	1,06
91	5 375,00	18,960	1,29
92	5 500,00	19,095	1,49
93	5 625,00	19,226	1,66
94	5 750,00	19,356	1,81
95	5 875,00	19,482	1,95
96	6 000,00	19,606	2,08
97	6 250,00	19,847	2,33
98	6 500,00	20,079	2,59
99	6 750,00	20,300	2,86
100	7 000,00	20,513	3,17
101	7 250,00	20,717	3,51
102	7 500,00	20,912	3,89
103	7 750,00	21,098	4,31
104	8 000,00	21,275	4,79
105	8 250,00	21,445	5,31
106	8 500,00	21,606	5,88
107	8 750,00	21,760	6,50
108	9 000,00	21,906	7,19
109	9 250,00	22,046	7,93
110	9 500,00	22,178	8,75
111	9 750,00	22,304	9,63
112	10 000,00	22,424	10,58
113	10 250,00	22,538	11,60
114	10 500,00	22,646	12,71
115	10 750,00	22,749	13,90
116	11 000,00	22,847	15,18
117	11 250,00	22,941	16,54
118	11 500,00	23,030	18,01
119	11 750,00	23,114	19,57
120	12 000,00	23,195	21,23
121	12 250,00	23,272	23,01
122	12 500,00	23,345	24,90
123	12 750,00	23,415	26,90
124	13 000,00	23,482	29,03
125	13 250,00	23,546	31,28
126	13 500,00	23,607	33,67
127	13 750,00	23,666	36,19
128	14 000,00	23,722	38,86
129	14 250,00	23,775	41,67
130	14 500,00	23,827	44,63
131	14 750,00	23,876	47,76
132	15 000,00	23,923	51,04

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Table D.1e. -- Frequencies, Critical Band Rates and Absolute Threshold
Table is valid for Layer II at a sampling rate of 44,1 kHz.

Index Number i	Frequency [Hz]	Crit.Band Rate [z]	Absolute Thresh. [dB]
1	43,07	0,425	45,05
2	86,13	0,850	25,87
3	129,20	1,273	18,70
4	172,27	1,694	14,85
5	215,33	2,112	12,41
6	258,40	2,525	10,72
7	301,46	2,934	9,47
8	344,53	3,337	8,50
9	387,60	3,733	7,73
10	430,66	4,124	7,10
11	473,73	4,507	6,56
12	516,80	4,882	6,11
13	559,86	5,249	5,72
14	602,93	5,608	5,37
15	646,00	5,959	5,07
16	689,06	6,301	4,79
17	732,13	6,634	4,55
18	775,20	6,959	4,32
19	818,26	7,274	4,11
20	861,33	7,581	3,92
21	904,39	7,879	3,74
22	947,46	8,169	3,57
23	990,53	8,450	3,40
24	1 033,59	8,723	3,25
25	1 076,66	8,987	3,10
26	1 119,73	9,244	2,95
27	1 162,79	9,493	2,81
28	1 205,86	9,734	2,67
29	1 248,93	9,968	2,53
30	1 291,99	10,195	2,39
31	1 335,06	10,416	2,25
32	1 378,13	10,629	2,11
33	1 421,19	10,836	1,97
34	1 464,26	11,037	1,83
35	1 507,32	11,232	1,68
36	1 550,39	11,421	1,53
37	1 593,46	11,605	1,38
38	1 636,52	11,783	1,23
39	1 679,59	11,957	1,07
40	1 722,66	12,125	0,90
41	1 765,72	12,289	0,74
42	1 808,79	12,448	0,56
43	1 851,86	12,603	0,39
44	1 894,92	12,753	0,21
45	1 937,99	12,900	0,02
46	1 981,05	13,042	-0,17
47	2 024,12	13,181	-0,36
48	2 067,19	13,317	-0,56
49	2 153,32	13,578	-0.96
50	2 239,45	13,826	-1,38
51	2 325,59	14,062	-1,79
52	2 411,72	14,288	-2,21
53	2 497,85	14,504	-2,63
54	2 583,98	14,711	-3,03
55	2 670,12	14,909	-3,41
56	2 756,25	15,100	-3,77
57	2 842,38	15,284	-4,09
58	2 928,52	15,460	-4,37
59	3 014,65	15,631	-4,60
60	3 100,78	15,796	-4,78
61	3 186,91	15,955	-4,91
62	3 273,05	16,110	-4,97
63	3 359,18	16,260	-4,98
64	3 445,31	16,406	-4,92
65	3 531,45	16,547	-4,81
66	3 617,58	16,685	-4,65
67	3 703,71	16,820	-4,43
68	3 789,84	16.951	-4,17
69	3 875,98	17,079	-3,87
70	3 962,11	17,205	-3,54
71	4 048,24	17,327	-3,19
72	4 134,38	17,447	-2,82
73	4 306,64	17,680	-2,06
74	4 478,91	17,905	-1,32
75	4 651,17	18,121	-0,64
76	4 823,44	18,331	-0,04
77	4 995,70	18,534	0,47
78	5 167,97	18,731	0,89
79	5 340,23	18,922	1,23
80	5 512,50	19,108	1,51
81	5 684,77	19,289	1,74
82	5 857,03	19,464	1,93
83	6 029,30	19,635	2,11
84	6 201,56	19,801	2,28
85	6 373,83	19,963	2,46
86	6 546,09	20,120	2,63
87	6 718,36	20,273	2,82
88	6 890,63	20,421	3,03
89	7 062,89	20,565	3,25
90	7 235,16	20,705	3,49
91	7 407,42	20,840	3,74
92	7 579,69	20,972	4,02
93	7 751,95	21,099	4,32
94	7 924,22	21,222	4,64
95	8 096,48	21,342	4,98
96	8 268,75	21,457	5,35
97	8 613,28	21,677	6,15
98	8 957,81	21,882	7,07
99	9 302,34	22,074	8,10
100	9 646,88	22,253	9,25
101	9 991,41	22,420	10,54
102	10 335,94	22,576	11,97
103	10 680,47	22,721	13,56
104	11 025,00	22,857	15,31
105	11 369,53	22,984	17,23
106	11 714,06	23,102	19,34
107	12 058,59	23,213	21,64
108	12 403,13	23,317	24,15
109	12 747,66	23,415	26,88
110	13 092,19	23,506	29,84
111	13 436,72	23,592	33,05
112	13 781,25	23,673	36,52
113	14 125,78	23,749	40,25
114	14 470,31	23,821	44,27
115	14 814,84	23,888	48,59
116	15 159,38	23,952	53,22
117	15 503,91	24,013	58,18
118	15 848,44	24,070	63,49
119	16 192,97	24,125	68,00
120	16 537,50	24,176	68,00
121	16 882,03	24,225	68,00
122	17 226,56	24,271	68,00
123	17 571,09	24,316	68,00
124	17 915,63	24,358	68,00
125	18 260,16	24,398	68,00
126	18 604,69	24,436	68,00
127	18 949,22	24,473	68,00
128	19 293,75	24,508	68,00
129	19 638,28	24,542	68,00
130	19 982,81	24,574	68,00

Table D.1f. -- Frequencies, critical band rates and absolute threshold
Table is valid for Layer II at a sampling rate of 48 kHz

Index Number i	Frequency [Hz]	Crit.Band Rate [z]	Absolute Thresh. [dB]
1	46,88	0,463	42,10
2	93,75	0,925	24,17
3	140,63	1,385	17,47
4	187,50	1,842	13,87
5	234,38	2,295	11,60
6	281,25	2,742	10,01
7	328,13	3,184	8,84
8	375,00	3,618	7,94
9	421,88	4,045	7,22
10	468,75	4,463	6,62
11	515,63	4,872	6,12
12	562,50	5,272	5,70
13	609,38	5,661	5,33
14	656,25	6,041	5,00
15	703,13	6,411	4,71
16	750,00	6,770	4,45
17	796,88	7,119	4,21
18	843,75	7,457	4,00
19	890,63	7,785	3,79
20	937,50	8,103	3,61
21	984,38	8,410	3,43
22	1 031,25	8,708	3,26
23	1 078,13	8,996	3,09
24	1 125,00	9,275	2,93
25	1 171,88	9,544	2,78
26	1 218,75	9,805	2,63
27	1 265,63	10,057	2,47
28	1 312,50	10,301	2,32
29	1 359,38	10,537	2,17
30	1 406,25	10,765	2,02
31	1 453,13	10,986	1,86
32	1 500,00	11,199	1,71
33	1 546,88	11.406	1,55
34	1 593,75	11,606	1,38
35	1 640,63	11,800	1,21
36	1 687,50	11,988	1,04
37	1 734,38	12,170	0,86
38	1 781,25	12,347	0,67
39	1 828,13	12,518	0,49
40	1 875,00	12,684	0,29
41	1 921,88	12,845	0,09
42	1 968,75	13,002	-0,11
43	2 015,63	13,154	-0,32
44	2 062,50	13,302	-0,54
45	2 109,38	13,446	-0,75
46	2 156,25	13,586	-0,97
47	2 203,13	13,723	-1,20
48	2 250,00	13.855	-1,43
49	2 343,75	14,111	-1,88
50	2 437,50	14,354	-2,34
51	2 531,25	14,585	-2,79
52	2 625,00	14,807	-3,22
53	2 718,75	15,018	-3,62
54	2 812,50	15,221	-3,98
55	2 906,25	15,415	-4,30
56	3 000,00	15,602	-4,57
57	3 093,75	15,783	-4,77
58	3 187,50	15,956	-4,91
59	3 281,25	16,124	-4,98
60	3 375,00	16,287	-4,97
61	3 468,75	16,445	-4,90
62	3 562,50	16,598	-4,76
63	3 656,25	16,746	-4,55
64	3 750,00	16,891	-4,29
65	3 843,75	17,032	-3,99
66	3 937,50	17,169	-3,64
67	4 031,25	17,303	-3,26
68	4 125,00	17,434	-2,86
69	4 218,75	17,563	-2,45
70	4 312,50	17,688	-2,04
71	4 406,25	17,811	-1,63
72	4 500,00	17,932	-1,24
73	4 687,50	18,166	-0,51
74	4 875,00	18,392	0,12
75	5 062,50	18,611	0,64
76	5 250,00	18,823	1,06
77	5 437,50	19,028	1,39
78	5 625,00	19,226	1,66
79	5 812,50	19,419	1,88
80	6 000,00	19,606	2,08
81	6 187,50	19,788	2,27
82	6 375,00	19,964	2,46
83	6 562,50	20,135	2,65
84	6 750,00	20,300	2,86
85	6 937,50	20,461	3,09
86	7 125,00	20,616	3,33
87	7 312,50	20,766	3,60
88	7 500,00	20,912	3,89
89	7 687,50	21,052	4,20
90	7 875,00	21,188	4,54
91	8 062,50	21,318	4,91
92	8 250,00	21,445	5,31
93	8 437,50	21,567	5,73
94	8 625,00	21,684	6,18
95	8 812,50	21,797	6,67
96	9 000,00	21,906	7,19
97	9 375,00	22,113	8,33
98	9 750,00	22,304	9,63
99	10 125,00	22,482	11,08
100	10 500,00	22,646	12,71
101	10 875,00	22,799	14,53
102	11 250,00	22,941	16,54
103	11 625,00	23,072	18,77
104	12 000,00	23,195	21,23
105	12 375,00	23,309	23,94
106	12 750,00	23,415	26,90
107	13 125,00	23,515	30,14
108	13 500,00	23,607	33,67
109	13 875,00	23,694	37,51
110	14 250,00	23,775	41,67
111	14 625,00	23,852	46,17
112	15 000,00	23,923	51,04
113	15 375,00	23,991	56,29
114	15 750,00	24,054	61,94
115	16 125,00	24,114	68,00
116	16 500,00	24,171	68,00
117	16 875,00	24,224	68,00
118	17 250,00	24,275	68,00
119	17 625,00	24,322	68,00
120	18 000,00	24,368	68,00
121	18 375,00	24,411	68,00
122	18 750,00	24,452	68,00
123	19 125,00	24,491	68,00
124	19 500,00	24,528	68,00
125	19 875,00	24,564	68,00
126	20 250,00	24,597	68,00

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Table D.2a. -- Critical band boundaries
This table is valid for Layer I at a sampling rate of 32 kHz.
The frequencies represent the top end of each critical band.

no	index of Table F&CB	frequency [Hz]	Bark [z]
0	1	62,500	0,617
1	3	187,500	1,842
2	5	312,500	3,037
3	7	437,500	4,185
4	9	562,500	5,272
5	11	687,500	6,289
6	13	812,500	7,233
7	15	937,500	8,103
8	18	1 125,000	9,275
9	21	1 312,500	10,301
10	24	1 500,000	11,199
11	27	1 687,500	11,988
12	32	2 000,000	13,104
13	37	2 312,500	14,027
14	44	2 750,000	15,087
15	50	3 250,000	16,069
16	55	3 875,000	17,078
17	61	4 625,000	18,089
18	68	5 500,000	19,095
19	74	6 500,000	20,079
20	79	7 750,000	21,098
21	85	9 250,000	22,046
22	94	11 500,000	23,030
23	108	15 000,000	23,923

Table D.2b. -- Critical band boundaries
This table is valid for Layer I at a sampling rate of 44,1 kHz.
The frequencies represent the top end of each critical band.

no	index of Table F&CB	frequency [Hz]	Bark [z]
0	1	86,133	0,850
1	2	172,266	1,694
2	3	258,398	2,525
3	5	430,664	4,124
4	6	516,797	4,882
5	8	689,063	6,301
6	9	775,195	6,959
7	11	947,461	8,169
8	13	1 119,727	9,244
9	15	1 291,992	10,195
10	17	1 464,258	11,037
11	20	1 722,656	12,125
12	23	1 981,055	13,042
13	27	2 325,586	14,062
14	32	2 756,250	15,100
15	37	3 186,914	15,955
16	45	3 875,977	17,079
17	50	4 478,906	17,904
18	55	5 340,234	18,922
19	61	6 373,828	19,963
20	68	7 579,688	20,971
21	75	9 302,344	22,074
22	81	11 369,531	22,984
23	93	15 503,906	24,013
24	106	19 982,813	24,573

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Table D.2c. -- Critical band boundaries
This table is valid for Layer I at a sampling rate of 48 kHz.
The frequencies represent the top end of each critical band.

no	indexof TableF&CB	frequency(Hz)	Bark[z]
0	1	93,750	0,925
1	2	187,500	1,842
2	3	281,250	2,742
3	4	375,000	3,618
4	5	468,750	4,463
5	6	562,500	5,272
6	7	656,250	6,041
7	9	843,750	7,457
8	10	937,500	8,103
9	12	1 125,000	9,275
10	14	1 312,500	10,301
11	16	1 500,000	11,199
12	19	1 781,250	12,347
13	21	1 968,750	13,002
14	25	2 343,750	14,111
15	29	2 718,750	15,018
16	35	3 281,250	16,124
17	41	3 843,750	17,032
18	49	4 687,500	18,166
19	53	5 437,500	19,028
20	58	6 375,000	19,964
21	65	7 687,500	21,052
22	73	9 375,000	22,113
23	79	11 625,000	23,072
24	89	15 375,000	23,991
25	102	20 250,000	24,597

Table D.2d. -- Critical band boundaries
This table is valid for Layer II at a sampling rate of 32 kHz.
The frequencies represent the top end of each critical band.

no	indexof TableF&CB	frequency[Hz]	Bark[z]
0	1	31,250	0,309
1	3	93,750	0,925
2	6	187,500	1,842
3	10	312,500	3,037
4	13	406,250	3,903
5	17	531,250	5,006
6	21	656,250	6,041
7	25	781,250	7,004
8	30	937,500	8,103
9	35	1 093,750	9,090
10	41	1 281,250	10,139
11	47	1 468,750	11,058
12	51	1 687,500	11,988
13	56	2 000,000	13,104
14	61	2 312,500	14,027
15	68	2 750,000	15,087
16	74	3 250,000	16,069
17	79	3 875,000	17,078
18	85	4 625,000	18,089
19	92	5 500,000	19,095
20	98	6 500,000	20,079
21	103	7 750,000	21,098
22	109	9 250,000	22,046
23	118	11 500,000	23,030
24	132	15 000,000	23,923

Table D.2e. -- Critical band boundaries
This table is valid for Layer II at a sampling rate of 44,1 kHz.
The frequencies represent the top end of each critical band.

no	indexof TableF&CB	frequency[Hz]	Bark[z]
0	1	43,066	0,425
1	2	86,133	0,850
2	3	129,199	1,273
3	5	215,332	2,112
4	7	301,465	2,934
5	10	430,664	4,124
6	13	559,863	5,249
7	16	689,063	6,301
8	19	818,262	7,274
9	22	947,461	8,169
10	26	1 119,727	9,244
11	30	1 291,992	10,195
12	35	1 507,324	11,232
13	40	1 722,656	12,125
14	46	1 981,055	13,042
15	51	2 325,586	14,062
16	56	2 756,250	15,100
17	62	3 273,047	16,11
18	69	3 875,977	17,079
19	74	4 478,906	17,904
20	79	5 340,234	18,922
21	85	6 373,828	19,963
22	92	7 579,688	20,971
23	99	9 302,344	22,074
24	105	11 369,531	22,984
25	117	15 503,906	24,013
26	130	19 982,813	24,573

Table D.2f. -- Critical band boundaries
This table is valid for Layer II at a sampling rate of 48 kHz.
The frequencies represent the top end of each critical band.

no	index of Table F&CB	frequency [Hz]	Bark [z]
0	1	46,875	0,463
1	2	93,750	0,925
2	3	140,625	1,385
3	5	234,375	2,295
4	7	328,125	3,184
5	9	421,875	4,045
6	12	562,500	5,272
7	14	656,250	6,041
8	17	796,875	7,119
9	20	937,500	8,103
10	24	1 125,000	9,275
11	27	1 265,625	10,057
12	32	1 500,000	11,199
13	37	1 734,375	12,170
14	42	1 968,750	13,002
15	49	2 343,750	14,111
16	53	2 718,750	15,018
17	59	3 281,250	16,124
18	65	3 843,750	17,032
19	73	4 687,500	18,166
20	77	5 437,500	19,028
21	82	6 375,000	19,964
22	89	7 687,500	21,052
23	97	9 375,000	22,113
24	103	11 625,000	23,072
25	113	15 375,000	23,991
26	126	20 250,000	24,597

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D.2 Psychoacoustic model 2

D.2.1 General

Psychoacoustic Model 2 is an independent psychoacoustic model that can be adjusted and adapted to any ISO/IEC 11172-3 layer. This annex presents the general Psychoacoustic Model 2, and provides sufficient information for implementation of Model 2 with Layers I and II. The Layer III psychoacoustic model is based on this implementation, with adaptations as described in the Layer III encoder.

The threshold generation process has three inputs. They are:

a) The shift length for the threshold calculation process, *iblen*, where $384 < iblen < 640$. This *iblen* must remain constant over any particular application of the threshold calculation process. If (as in Layer III), it is necessary to calculate thresholds for two different shift lengths, two processes, each running with a fixed shift length, will be necessary. In the case of *iblen* outside the range of 384 to 640 it may be necessary to calculate the psychoacoustic thresholds with a different window length as well as shift length. There are two ways to do this:

   - Use a different length transform, and recalculate the startup coefficients for the model, or

   - Use the same length transform, but a substantially shorter Hann window, appropriate to the data and problem at hand.

   The choice of these is left to the implementation.

b) The newest *iblen* samples of the signal, with the samples delayed (either in the filter bank or psychoacoustic calculation) such that the window of the psychoacoustic calculation is centered in the time-window of application.

c) The sampling rate. There are sets of tables provided for the standard sampling rates. Sampling rate, like *iblen*, must necessarily remain constant over one implementation of the threshold calculation process.

There is one output from Psychoacoustic Model 2, a set of Signal-to-Masking Ratios, SMR_n, which are adapted to the layers as described below.

Before running the model initially, the array used to hold the preceding FFT source data window and the arrays used to hold r and f should be zeroed to provide a known starting point.

In Layer II, the psychoacoustic masking ratios must be calculated twice during each coder frame. The more stringent of each pair of ratios is used for bit allocation as shown in the software simulation model for Layers I and II with Psychoacoustic Model 2.

D.2.2 Comments on notation

Throughout this threshold calculation process, three indices for data values are used. These are:

ω - indicates that the calculation is indexed by frequency in the FFT spectral line domain. An index of 1 corresponds to the DC term and an index of 513 corresponds to the spectral line at the Nyquist frequency.

b - indicates that the calculation is indexed in the threshold calculation partition domain. In the case where the calculation includes a convolution or sum in the threshold calculation partition domain, *bb* will be used as the summation variable. Partition numbering starts at 1.

n - indicates that the calculation is indexed in the coder bit (or codebook) allocation domain. An index of 1 corresponds to the lowest band in the subband filter bank.

D.2.3 The "spreading function"

Several points in the following description refer to the "spreading function". It is calculated by the following method:

$$tmpx = 1{,}05\ (j - i),$$

Where i is the Bark value of the signal being spread, j is the Bark value of the band being spread into, and $tmpx$ is a temporary variable.

$$x = 8\ minimum\ ((tmpx-0{,}5)^2 - 2(tmpx-0{,}5), 0)$$

Where x is a temporary variable, and minimum (a,b) is a function returning the more negative of a or b.

$$tmpy = 15{,}811389 + 7{,}5(tmpx+0{,}474) - 17{,}5(1{,}0+(tmpx+0{,}474)^2)^{0{,}5}$$

where $tmpy$ is another temporary variable.

$$\text{if } (tmpy < -100) \text{ then } \{sprdngf(i,j) = 0\} \text{ else } \{sprdngf(i,j) = 10^{\frac{(x + tmpy)}{10}}\}$$

D.2.4 Steps in threshold calculation

The following are the necessary steps for calculation of the SMR_n used in the coder.

a) Reconstruct 1 024 samples of the input signal.

iblen new samples are made available at every call to the threshold generator. The threshold generator must store 1 024-*iblen* samples, and concatenate those samples to accurately reconstruct 1 024 consecutive samples of the input signal, s_i, where i represents the index, $1 <= i <= 1\,024$ of the current input stream.

b) Calculate the complex spectrum of the input signal.

First, s_i is windowed by a 1 024 point Hann window, i.e. $sw_i = s_i * (0{,}5 - 0{,}5\cos(\frac{2\pi(i - 0{,}5)}{1024}))$. Note that in Layer III, a shorter window may be used when window switching is active, with appropriate centering of the window, per the Layer III encoder description.

Second, a standard forward FFT of sw_i is calculated.

Third, the polar representation of the transform is calculated. r_ω and f_ω represent the magnitude and phase components of the transformed sw_i, respectively.

c) Calculate a predicted r and f.

A predicted magnitude, $\hat{r}_\omega$, and phase, $\hat{f}_\omega$ are calculated from the preceding two threshold calculation blocks' r and f:

$$\hat{r}_\omega = 2{,}0 r_\omega(t-1) - r_\omega(t-2)$$

$$\hat{f}_\omega = 2{,}0 f_\omega(t-1) - f_\omega(t-2)$$

where t represents the current block number, $t-1$ indexes the previous block's data, and $t-2$ indexes the data from the threshold calculation block before that.

d) Calculate the unpredictability measure c_ω

c_ω, the unpredictability measure, is:

$$c_\omega = \frac{((r_\omega \cos f_\omega - \hat{r}_\omega \cos \hat{f}_\omega)^2 + (r_\omega \sin f_\omega - \hat{r}_\omega \sin \hat{f}_\omega)^2)^{0,5}}{r_\omega + \mathrm{abs}(\hat{r}_\omega)}$$

By sacrificing performance, this measure can be calculated on only a lower portion of the frequency lines. Calculations should be done from DC to at least 3 kHz and preferably to 7kHz. An upper limit of less than 5,5kHz may considerably reduce performance from that obtained during the subjective testing of the audio algorithm. The c_ω values above this limit should be set to 0,3. Best results will be obtained by calculating c_ω up to 20 kHz.

e) Calculate the energy and unpredictability in the threshold calculation partitions.

The energy in each partition, e_b, is:

$$e_b = \sum_{\omega=\omega low_b}^{\omega high_b} r_\omega^2$$

and the weighted unpredictability, c_b, is:

$$c_b = \sum_{\omega=\omega low_b}^{\omega high_b} r_\omega^2 c_\omega$$

The threshold calculation partitions provide a resolution of approximately either one FFT line or $\frac{1}{3}$ critical band, whichever is wider. At low frequencies, a single line of the FFT will constitute a calculation partition. At high frequencies, many lines will be combined into one calculation partition. A set of partition values is provided for each of the three sampling rates in table D.3."Calculation partition tables". These table elements will be used in the threshold calculation process. There are several elements in each table entry:

1. The index of the calculation partition, b.
2. The lowest frequency line in the partition, ωlow_b.
3. The highest frequency line in the partition, $\omega high_b$.
4. The median bark value of the partition, $bval_b$.
5. A lower limit for the SNR in the partition that controls stereo unmasking effects, $minval_b$.
6. The value for tone masking noise (in dB) for the partition, TMN_b.

A largest value of b, $bmax$, equal to the largest index, exists for each sampling rate.

f) Convolve the partitioned energy and unpredictability with the spreading function.

$$ecb_b = \sum_{bb=1}^{bmax} e_{bb} * sprdngf(bval_{bb}, bval_b)$$

$$ct_b = \sum_{bb=1}^{bmax} c_{bb} * sprdngf(bval_{bb}, bval_b)$$

Because ct_b is weighted by the signal energy, it must be renormalized to cb_b.

$$cb_b = \frac{ct_b}{ecb_b}$$

At the same time, due to the non-normalized nature of the spreading function, ecb_b should be renormalized and the normalized energy en_b, calculated.

$$en_b = ecb_b * rnorm_b$$

The normalization coefficient, $rnorm_b$. is:

$$rnorm_b = \frac{1}{\sum_{bb=0}^{bmax} sprdngf(bval_{bb}, bval_b)}$$

g) Convert cb_b to tb_b, the tonality index.

$$tb_b = -0{,}299 - 0{,}43 \log_e (cb_b)$$

Each tb_b is limited to the range of $0 < tb_b < 1$.

h) Calculate the required SNR in each partition.

NMT_b = 5,5dB for all b. NMT_b is the value for noise masking tone (in dB) for the partition. The required signal to noise ratio, SNR_b, is:

$$SNR_b = \text{maximum}(minval_b, tb_b * TMN_b + (1-tb_b) * NMT_b)$$

Where maximum (a,b) is a function returning the least negative of a or b.

i) Calculate the power ratio.

The power ratio, bc_b, is:

$$bc_b = 10^{\frac{-SNR_b}{10}}$$

j) Calculation of actual energy threshold, nb_b.

$$nb_b = en_b \, bc_b$$

k) Spread the threshold energy over FFT lines, yielding nb_ω.

$$nb_\omega = \frac{nb_b}{\omega high_b - \omega low_b + 1}$$

l) Include absolute thresholds, yielding the final energy threshold of audibility, thr_ω

$$thr_\omega = \max(nb_\omega, absthr_\omega)$$

The dB values of *absthr* shown in tables D.4. "Absolute threshold tables" are relative to the level that a sine wave of $\pm \frac{1}{2}$ lsb has in the FFT used for threshold calculation. The dB values must be converted into the energy domain after considering the FFT normalization actually used.

m) Pre-echo control

For Layer III, pre-echo control occurs at this point. The actual control is described as part of the Layer III encoder specification. This step is omitted for Layers I and II.

n) Calculate the signal-to-mask ratios, SMR_n.

Table D.5. "Layer I and II coder partition table" shows:

1. The index, n, of the coder partition.

2. The lower index ωlow_n, of the coder partition.

3. The upper index, $\omega high_n$ of the coder partition.

4. The width index, $width_n$, where $width_n$=1 for a psychoacoustically narrow scalefactor band, and $width_n$=0 for a psychoacoustically wide scalefactor band. A psychoacoustically narrow scalefactor band is one whose width is less than approximately $\frac{1}{3}$ critical band.

The energy in the scalefactor band, $epart_n$, is:

$$epart_n = \sum_{\omega=\omega low_n}^{\omega high_n} r_\omega^2$$

Then, if ($width_n$ = 1), the noise level in the scalefactor band, $npart_n$ is calculated as:

$$npart_n = \sum_{\omega=\omega low_n}^{\omega high_n} thr_\omega$$

else,

$$npart_n = \text{minimum}(thr_{\omega low_n},...,thr_{\omega high_n}) * (\omega high_n - \omega low_n + 1)$$

Where, in this case, minimum (a,...,z) is a function returning the smallest positive argument of the arguments a...z.

The ratios to be sent to the coder, SMR_n , are calculated as:

$$SMR_n = 10 \log_{10} \left(\frac{epart_n}{npart_n} \right)$$

Table D.3a. -- Calculation partition table
This table is valid at a sampling rate of 32 kHz.

Index	ωlow	ωhigh	bval	minval	TMN
1	1	1	0,00	0,0	24,5
2	2	4	0,63	0,0	24,5
3	5	7	1,56	20,0	24,5
4	8	10	2,50	20,0	24,5
5	11	13	3,44	20,0	24,5
6	14	16	4,34	20,0	24,5
7	17	19	5,17	20,0	24,5
8	20	22	5,94	20,0	24,5
9	23	25	6,63	17,0	24,5
10	26	28	7,28	15,0	24,5
11	29	31	7,90	15,0	24,5
12	32	34	8,50	10,0	24,5
13	35	37	9,06	7,0	24,5
14	38	41	9,65	7,0	24,5
15	42	45	10,28	4,4	24,8
16	46	49	10,87	4,4	25,4
17	50	53	11,41	4,5	25,9
18	54	57	11,92	4,5	26,4
19	58	61	12,39	4,5	26,9
20	62	65	12,83	4,5	27,3
21	66	70	13,29	4,5	27,8
22	71	75	13,78	4,5	28,3
23	76	81	14,27	4,5	28,8
24	82	87	14,76	4,5	29,3
25	88	93	15,22	4,5	29,7
26	94	99	15,63	4,5	30,1
27	100	106	16,06	4,5	30,6
28	107	113	16,47	4,5	31,0
29	114	120	16,86	4,5	31,4
30	121	129	17,25	4,5	31,8
31	130	138	17,65	4,5	32,2
32	139	148	18,05	4,5	32,5
33	149	159	18,42	4,5	32,9
34	160	170	18,81	4,5	33,3
35	171	183	19,18	4,5	33,7
36	184	196	19,55	4,5	34,1
37	197	210	19,93	4,5	34,4
38	211	225	20,29	4,5	34,8
39	226	240	20,65	4,5	35,2
40	241	258	21,02	4,5	35,5
41	259	279	21,38	4,5	35,9
42	280	300	21,74	4,5	36,2
43	301	326	22,10	4,5	36,6
44	327	354	22,44	4,5	36,9
45	355	382	22,79	4,5	37,3
46	383	420	23,14	4,5	37,6
47	421	458	23,49	4,5	38,0
48	459	496	23,83	4,5	38,3
49	497	513	24,07	4,5	38,6

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Table D.3b. -- Calculation partition table
This table is valid at a sampling rate of 44,1 kHz.

Index	ωlow	ωhigh	bval	minval	TMN
1	1	1	0,00	0,0	24,5
2	2	2	0,43	0,0	24,5
3	3	3	0,86	0,0	24,5
4	4	4	1,29	20,0	24,5
5	5	5	1,72	20,0	24,5
6	6	6	2,15	20,0	24,5
7	7	7	2,58	20,0	24,5
8	8	8	3,01	20,0	24,5
9	9	9	3,45	20,0	24,5
10	10	10	3,88	20,0	24,5
11	11	11	4,28	20.0	24,5
12	12	12	4,67	20,0	24,5
13	13	13	5,06	20,0	24,5
14	14	14	5,42	20,0	24,5
15	15	15	5,77	20,0	24,5
16	16	16	6,11	17,0	24,5
17	17	19	6,73	17,0	24,5
18	20	22	7,61	15,0	24,5
19	23	25	8,44	10,0	24,5
20	26	28	9,21	7,0	24,5
21	29	31	9,88	7,0	24,5
22	32	34	10,51	4,4	25,0
23	35	37	11,11	4,5	25,6
24	38	40	11,65	4,5	26,2
25	41	44	12,24	4,5	26,7
26	45	48	12,85	4,5	27,4
27	49	52	13,41	4,5	27,9
28	53	56	13,94	4,5	28,4
29	57	60	14,42	4,5	28,9
30	61	64	14,86	4,5	29,4
31	65	69	15,32	4,5	29,8
32	70	74	15,79	4,5	30,3
33	75	80	16,26	4,5	30,8
34	81	86	16,73	4,5	31,2
35	87	93	17,19	4,5	31,7
36	94	100	17,62	4,5	32,1
37	101	108	18,05	4,5	32,5
38	109	116	18,45	4,5	32,9
39	117	124	18,83	4,5	33,3
40	125	134	19,21	4,5	33,7
41	135	144	19,60	4,5	34,1
42	145	155	20,00	4,5	34,5
43	156	166	20,38	4,5	34,9
44	167	177	20,74	4,5	35,2
45	178	192	21,12	4,5	35,6
46	193	207	21,48	4,5	36,0
47	208	222	21,84	4,5	36,3
48	223	243	22,20	4,5	36,7
49	244	264	22,56	4.5	37.1
50	265	286	22,91	4,5	37,4
51	287	314	23,26	4,5	37,8
52	315	342	23,60	4,5	38,1
53	343	371	23,95	4,5	38,4
54	372	401	24,30	4,5	38,8
55	402	431	24,65	4,5	39,1
56	432	469	25,00	4,5	39,5
57	470	513	25,33	3,5	39,8

Table D.3c. -- Calculation partition table
This table is valid at a sampling rate of 48 kHz.

Index	ωlow	ωhigh	bval	minval	TMN
1	1	1	0,00	0,0	24,5
2	2	2	0,47	0,0	24,5
3	3	3	0,94	0,0	24,5
4	4	4	1,41	20,0	24,5
5	5	5	1,88	20,0	24,5
6	6	6	2,34	20,0	24,5
7	7	7	2,81	20,0	24,5
8	8	8	3,28	20,0	24,5
9	9	9	3,75	20,0	24,5
10	10	10	4,20	20,0	24,5
11	11	11	4,63	20,0	24,5
12	12	12	5,05	20,0	24,5
13	13	13	5,44	20,0	24,5
14	14	14	5,83	20,0	24,5
15	15	15	6,19	20,0	24,5
16	16	16	6,52	17,0	24,5
17	17	17	6,86	17,0	24,5
18	18	20	7,49	15,0	24,5
19	21	23	8,40	10,0	24,5
20	24	26	9,24	7,0	24,5
21	27	29	9,97	7,0	24,5
22	30	32	10,65	4,4	25,1
23	33	35	11,28	4,5	25,8
24	36	38	11,86	4,5	26,4
25	39	41	12,39	4,5	26,9
26	42	45	12,96	4,5	27,5
27	46	49	13,56	4,5	28,1
28	50	53	14,12	4,5	28,6
29	54	57	14,62	4,5	29,1
30	58	62	15,14	4,5	29,6
31	63	67	15,67	4,5	30,2
32	68	72	16,15	4,5	30,7
33	73	77	16,58	4,5	31,1
34	78	83	17,02	4,5	31,5
35	84	89	17,44	4,5	31,9
36	90	95	17,84	4,5	32,3
37	96	103	18,24	4,5	32,7
38	104	111	18,66	4,5	33,2
39	112	120	19,07	4,5	33,6
40	121	129	19,47	4,5	34,0
41	130	138	19,85	4,5	34,3
42	139	149	20,23	4,5	34,7
43	150	160	20,63	4,5	35,1
44	161	173	21,02	4,5	35,5
45	174	187	21,40	4,5	35,9
46	188	201	21,76	4,5	36,3
47	202	219	22,12	4,5	36,6
48	220	238	22,47	4,5	37,0
49	239	257	22,83	4,5	37,3
50	258	283	23,18	4,5	37,7
51	284	309	23,53	4,5	38,0
52	310	335	23,88	4,5	38,4
53	336	363	24,23	4,5	38,7
54	364	391	24,58	4,5	39,1
55	392	423	24,93	4,5	39,4
56	424	465	25,27	4,5	39,8
57	466	507	25,61	3,5	40,1
58	508	513	25,81	3,5	40,3

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Table D.4a. -- Absolute threshold table

This table is valid at a sampling rate of 32 kHz.

A value of 0 dB represents a level in the absolute threshold calculation of 96 dB below the energy of a sine wave of amplitude +-32 760.

index [line]		absthr
lower	higher	[dB]
1	1	58,23
2	2	33,44
3	3	24,17
4	4	19,20
5	5	16,05
6	6	13,87
7	7	12,26
8	8	11,01
9	9	10,01
10	10	9,20
11	11	8,52
12	12	7,94
13	13	7,44
14	14	7,00
15	15	6,62
16	16	6,28
17	17	5,97
18	18	5,70
19	19	5,44
20	20	5,21
21	21	5,00
22	22	4,80
23	23	4,62
24	24	4,45
25	25	4,29
26	26	4,14
27	27	4,00
28	28	3,86
29	29	3,73
30	30	3,61
31	31	3,49
32	32	3,37
33	33	3,26
34	34	3,15
35	35	3,04
36	36	2,93
37	37	2,83
38	38	2,73
39	39	2,63
40	40	2,53
41	41	2,42
42	42	2,32
43	43	2,22
44	44	2,12
45	45	2,02
46	46	1,92
47	47	1,81
48	48	1,71
49	50	1,49
51	52	1,27
53	54	1,04
55	56	0,80
57	57	0,55
59	60	0,29
61	62	0,02
63	64	-0,25
65	66	-0,54
67	68	-0,83
69	70	-1,12
71	72	-1,43
73	74	-1,73
75	76	-2,04
77	78	-2,34
79	80	-2,64
81	82	-2,93
83	84	-3,22
85	86	-3,49
87	88	-3,74
89	90	-3,98
91	92	-4,20
93	94	-4,40
95	96	-4,57
97	100	-4,82
101	104	-4,96
105	108	-4,97
109	112	-4,86
113	116	-4,63
117	120	-4,29
121	124	-3,87
125	128	-3,39
129	132	-2,86
133	136	-2,31
137	140	-1,77
141	144	-1,24
145	148	-0,74
149	152	-0,29
153	156	0,12
157	160	0,48
161	164	0,79
165	168	1,06
169	172	1,29
173	176	1,49
177	180	1,66
181	184	1,81
185	188	1,95
189	192	2,08
193	200	2,33
201	208	2,59
209	216	2,86
217	224	3,17
225	232	3,51
233	240	3,89
241	248	4,31
249	256	4,79
257	264	5,31
265	272	5,88
273	280	6,50
281	288	7,19
289	296	7,93
297	304	8,75
305	312	9,63
313	320	10,58
321	328	11,60
329	336	12,71
337	344	13,90
345	352	15,18
353	360	16,54
361	368	18,01
369	376	19,57
377	384	21,23
385	392	23,01
393	400	24,90
401	408	26,90
409	416	29,03
417	424	31,28
425	432	33,67
433	440	36,19
441	448	38,86
449	456	41,67
457	464	44,63
465	472	47,76
473	480	51,03

Table D.4b -- Absolute threshold table

This table is valid at a sampling rate of 44,1kHz.

A value of 0 dB represents a level in the absolute threshold calculation of 96dB below the energy of a sine wave of amplitude +-32 760.

index [line]		absthr
lower	higher	[dB]
1	1	45,05
2	2	25,87
3	3	18,70
4	4	14,85
5	5	12,41
6	6	10,72
7	7	9,47
8	8	8,50
9	9	7,73
10	10	7,10
11	11	6,56
12	12	6,11
13	13	5,72
14	14	5,37
15	15	5,07
16	16	4,79
17	17	4,55
18	18	4,32
19	19	4,11
20	20	3,92
21	21	3,74
22	22	3,57
23	23	3,40
24	24	3,25
25	25	3,10
26	26	2,95
27	27	2,81
28	28	2,67
29	29	2,53
30	30	2,39
31	31	2,25
32	32	2,11
33	33	1,97
34	34	1,83
35	35	1,68
36	36	1,53
37	37	1,38
38	38	1,23
39	39	1,07
40	40	0,90
41	41	0,74
42	42	0,56
43	43	0,39
44	44	0,21
45	45	0,02
46	46	-0,17
47	47	-0,36
48	48	-0,56
49	50	-0,96
51	52	-1,37
53	54	-1,79
55	56	-2,21
57	58	-2,63
59	60	-3,03
61	62	-3,41
63	64	-3,77
65	66	-4,09
67	68	-4,37
69	70	-4,60
71	72	-4,78
73	74	-4,91
75	76	-4,97
77	78	-4,98
79	80	-4,92
81	82	-4,81
83	84	-4,65
85	86	-4,43
87	88	-4,17
89	90	-3,87
91	92	-3,54
93	94	-3,19
95	96	-2,82
97	100	-2,06
101	104	-1,33
105	108	-0,64
109	112	-0,04
113	116	0,47
117	120	0,89
121	124	1,23
125	128	1,51
129	132	1,74
133	136	1,93
137	140	2,11
141	144	2,28
145	148	2,45
149	152	2,63
153	156	2,82
157	160	3,03
161	164	3,25
165	168	3,49
169	172	3,74
173	176	4,02
177	180	4,32
181	184	4,64
185	188	4,98
189	192	5,35
193	200	6,15
201	208	7,07
209	216	8,10
217	224	9,25
225	232	10,54
233	240	11,97
241	248	13,56
249	256	15,30
257	264	17,23
265	272	19,33
273	280	21,64
281	288	24,15
289	296	26,88
297	304	29,84
305	312	33,04
313	320	36,51
321	328	40,24
329	336	44,26
337	344	48,58
345	352	53,21
353	360	58,17
361	368	63,48
369	376	69,13
377	384	69,13
385	392	69,13
393	400	69,13
401	408	69,13
409	416	69,13
417	424	69,13
425	432	69,13
433	440	69,13
441	448	69,13
449	456	69,13
457	464	69,13

Table D.4c -- Absolute threshold table
This table is valid at a sampling rate of 48 kHz.

A value of 0 dB represents a level in the absolute threshold calculation of 96dB below the energy of a sine wave of amplitude +-32 760.

index [line]		absthr
lower	higher	[dB]
1	1	42,10
2	2	24,17
3	3	17,47
4	4	13,87
5	5	11,60
6	6	10,01
7	7	8,84
8	8	7,94
9	9	7,22
10	10	6,62
11	11	6,12
12	12	5,70
13	13	5,33
14	14	5,00
15	15	4,71
16	16	4,45
17	17	4,21
18	18	4,00
19	19	3,79
20	20	3,61
21	21	3,43
22	22	3,26
23	23	3,09
24	24	2,93
25	25	2,78
26	26	2,63
27	27	2,47
28	28	2,32
29	29	2,17
30	30	2,02
31	31	1,86
32	32	1,71
33	33	1,55
34	34	1,38
35	35	1,21
36	36	1,04
37	37	0,86
38	38	0,67
39	39	0,49
40	40	0,29
41	41	0,09
42	42	-0,11
43	43	-0,32
44	44	-0,54
45	45	-0,75
46	46	-0,97
47	47	-1,20

index [line]		absthr
lower	higher	[dB]
48	48	-1,43
49	50	-1,88
51	52	-2,34
53	54	-2,79
55	56	-3,22
57	58	-3,62
59	60	-3,98
61	62	-4,30
63	64	-4,57
65	66	-4,77
67	68	-4,91
69	70	-4,98
71	72	-4,97
73	74	-4,90
75	76	-4,76
77	78	-4,55
79	80	-4,29
81	82	-3,99
83	84	-3,64
85	86	-3,26
87	88	-2,86
89	90	-2,45
91	92	-2,04
93	94	-1,63
95	96	-1,24
97	100	-0,51
101	104	0,12
105	108	0,64
109	112	1,06
113	116	1,39
117	120	1,66
121	124	1,88
125	128	2,08
129	132	2,27
133	136	2,46
137	140	2,65
141	144	2,86
145	148	3,09
149	152	3,33
153	156	3,60
157	160	3,89
161	164	4,20
165	168	4,54
169	172	4,91
173	176	5,31
177	180	5,73
181	184	6,18

index [line]		absthr
lower	higher	[dB]
185	188	6,67
189	192	7,19
193	200	8,33
201	208	9,63
209	216	11,08
217	224	12,71
225	232	14,53
233	240	16,54
241	248	18,77
249	256	21,23
257	264	23,94
265	272	26,90
273	280	30,14
281	288	33,67
289	296	37,51
297	304	41,67
305	312	46,17
313	320	51,04
321	328	56,29
329	332	61,94
333	340	68,00
341	348	68,00
349	356	68,00
357	364	68,00
365	372	68,00
373	380	68,00
381	388	68,00
389	396	68,00
397	404	68,00
405	412	68,00
413	420	68,00
421	428	68,00

Table D.5 -- Layer I and Layer II coder partition table

Index	ωlow_{n+1} $\omega high_n$	$width_n$
0	1	0
1	17	0
2	33	0
3	49	0
4	65	0
5	81	0
6	97	0
7	113	0
8	129	0
9	145	0
10	161	0
11	177	0
12	193	0
13	209	1
14	225	1
15	241	1
16	257	1
17	273	1
18	289	1
19	305	1
20	321	1
21	337	1
22	353	1
23	369	1
24	385	1
25	401	1
26	417	1
27	433	1
28	449	1
29	465	1
30	481	1
31	497	1
32	513	1

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Annex E

(informative)

Bit sensitivity to errors

E.1. General

This annex indicates the sensitivity of individual bits to random errors if application specific error protection is needed.This sensitivity is given for each bit by a value from 0 to 5, indicating the amount of degradation resulting from one isolated error :

5 catastrophic
4 very annoying
3 annoying
2 slightly annoying
1 audible
0 insensitive

The values are not the results of precise measurements, rather they rely upon knowledge of the codec. They assume the error detection scheme is not in use.

Some fields in the bit stream do not have a fixed length. All bits in these fields are rated for error sensitivity, even if not in use.

For all layers, the header and error check information defined in 2.4.1.3 and 2.4.1.4 are considered to have the highest sensitivity.

E.2. Layers I and II

Parameters	#bit	sensitivity
Bit allocation	all bits	5
Scalefactors select information	all bits	5
Scalefactors	5 (msb)	4
	4	4
	3	4
	2	3
	1	2
	0 (lsb)	1
Subband samples (*)	8-16(msb)	3
	5-7	2
	3,4	1
	(lsb)0-2	0

(*) according to the bit allocation

E.3. Layer III

Parameters	#bit	sensitivity
scfsi	all bits	5
part2_3_length	all bits	4
big_values	all bits	3
global_gain	all bits	5
scalefac_compress	all bits	5
window_switching_flag	0	5
block_type	all bits	4
mixed_block_flag	0	4
table_select	all bits	5
region0_count	all bits	3
region1_count	all bits	3
preflag	0	2
scalefac_scale	0	2
count1table_select	0	3
Subblock_gain	2 (msb)	4
	1	3
	0 (lsb)	2
scale_fac (**)	3 (msb)	3(2)
	2	3(2)
	1	2(1)
	0 (lsb)	2(1)
Huffmancodebits () (***)	0...n-1	3 - 0

(**) the scalefac length depends on scalefac_compress.
The bit sensitivity values refer to the scalefac_scale value 1 (if 0 the value is in parenthesis).
(***) If n is the number of bits for Huffman coding in one block the bit sensivity decreases linearly from 3 to 0 as the bit number varies from 0 up to n, (from low to high frequency).

Note:
Rearrangement of the Huffman coded values:
To get better implicit error robustness for the low frequency part of the spectrum the Huffman coded values can be transmitted not in their logical order, but in an interleaved fashion.

If max_hlen is the maximum length of a Huffman codeword over the tables which are used to code the particular block and n is the number of bits used for Huffman coding of data in the block (not frame), then int(n/max_hlen) slots are filled with the first codewords, beginning from low frequencies. The remaining codewords are filled into the remaining place, again arranged from low to high frequencies.

After bit interleaving, the bit sensivity of bit k+i*int(n/max_hlen) decreases linearly from 3 to 0 as k varies from 0 up to int(n/max_hlen)-1, where i=0,...,max_hlen-1, and n is the number of bits for Huffman coding in one block.

This is the recommended practice for Layer III data for all channels where error robustness is important.

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Annex F

(informative)

Error concealment

An optional feature of the coded bit stream is the CRC word which provides some error detection facility to the decoder. The Hamming distance of this error detection code is d=4, which allows for the detection of up to 3 single bit errors or for the detection of one error burst of up to 16 bit length. The amount and the position of the protected bits within one encoded audio frame generally depends on the layer, the mode, data rate, and sampling frequency.

This can be used to control an error concealment strategy in order to avoid severe impairments of the reconstructed signal due to errors in the most sensitive information.

Some basic techniques can be used for concealment, for instance information substitution, or muting. A simple substitution technique consists, when an erroneous frame occurs, of replacing it by the previous one (if error free).

Annex G

(informative)

Joint stereo coding

G.1. Intensity stereo coding Layer I, II

An optional joint stereo coding method used in Layers I and II is intensity stereo coding. Intensity stereo coding can be used to increase the audio quality and/or reduce the bitrate for stereophonic signals. The gain in bitrate is typically about 10 to 30 kbits/s. It requires negligible additional decoder complexity. The increase of encoder complexity is small. The encoder and decoder delay is not affected.

Psychoacoustic results indicate that at high frequencies (above about 2 kHz) the localization of the stereophonic image within a critical band is determined by the temporal envelope and not by the temporal fine structure of the audio signal.

The basic idea for intensity stereo coding is that for some subbands, instead of transmitting separate left and right subband samples, only the sum-signal is transmitted, but with scalefactors for both the left and right channels, thus preserving the stereophonic image.

Flow diagrams of a stereo encoder and decoder, including intensity stereo mode, are shown in figure G.1 "General stereo encoder flow-chart" and figure G.2 "General stereo decoder flow-chart". First, an estimation is made of the required bitrate for both left and right channel. If the required bitrate exceeds the available bitrate, the required bitrate can be decreased by setting a number of subbands to intensity stereo mode. Depending on the bitrate needed, subbands

16 to 31,
12 to 31,
8 to 31, or
4 to 31

can be set to intensity stereo mode. For the quantization of such combined subbands, the higher of the bit allocations for left and right channel is used.

The left and right subband signals of the subbands in joint stereo mode are added. These new subband signals are scaled in the normal way, but the originally determined scalefactors of the left and right subband signals are transmitted according to the bitstream syntax. Quantization of common subband samples, coding of common samples, and coding of common bit allocation are performed in the same way as in independent coding.

G.2. MS_Stereo and intensity stereo coding Layer III

In Layer III a combination of ms_stereo mode (sum/difference) and intensity stereo mode can be used.

a) MS_stereo switching

MS_stereo mode is switched on if in joint stereo mode condition

$$\sum_{i=0}^{511} [\, rl_i^2 - rr_i^2 \,] < 0.8 * \sum_{i=0}^{511} [\, rl_i^2 + rr_i^2 \,]$$

is true. The values rl_i and rr_i correspond to the energies of the FFT line spectrum of the left and right channel calculated within the psychoacoustic model.

b) MS_stereo processing

- MS matrix

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In MS_stereo mode the values of the normalized middle/side channel M_i/S_i are transmitted instead of the left/right channel values L_i/R_i:

$$M_i = \frac{R_i + L_i}{\sqrt{2}} \quad \text{and} \quad S_i = \frac{L_i - R_i}{\sqrt{2}}$$

- Limitation of S_i channel bandwith

All S_i values above the highest scalefactor band are set to zero.

- Sparsing of S_i channel

In every scalefactor band sb all pairs of small values (S_i, S_{i+1}) are set to zero:

```
if (Si^2 + Si+1^2) < ssb * (Li^2 + Li+1^2 + Ri^2 + Ri+1^2) {
        Si = 0;  Si+1 = 0;
}
```

The following difference channel threshold coefficients apply to the scalefactor bands for block type != 2 ('long MDCT transforms'):

sb	0	1	2	3	4	5	6	7	8	9
s_{sb}	0,0	0,0	0,0	0,0	0,0	0,10	0,10	0,10	0,10	0,10

sb	10	11	12	13	14	15	16	17	18	19	20
s_{sb}	0,10	0,20	0,30	0,40	0,50	0,60	0,70	0,80	0,90	1,00	1,50

c) Intensity stereo processing

- Calculation of intensity stereo position

For each scalefactor band sb coded in intensity stereo the following steps are executed:

- $is\_pos_{sb} = \mathrm{NINT}\left(\frac{12}{\pi} * \arctan\left(\sqrt{\frac{L\_Energy_{sb}}{R\_Energy_{sb}}}\right)\right)$

- $L_i = L_i + R_i$ for all indices i within the actual scalefactor band sb

- $R_i = 0$ for all indices i within the actual scalefactor band sb

- the intensity stereo position is_pos_{sb} is transmitted instead of the scalefactor of the right channel (3 bits always, stereo positions 0..6, 7=illegal stereo position)

where $L\_Energy_{sb}/R\_Energy_{sb}$ denote the signal energies of the left/right channel within the actual scalefactor band and L_i/R_i are the transformed values.

Scalefactor bands of the right/difference channel containing only zeros after coding which do not belong to the intensity coded part should be transmitted with the scalefactor '7' to prevent intensity stereo decoding.

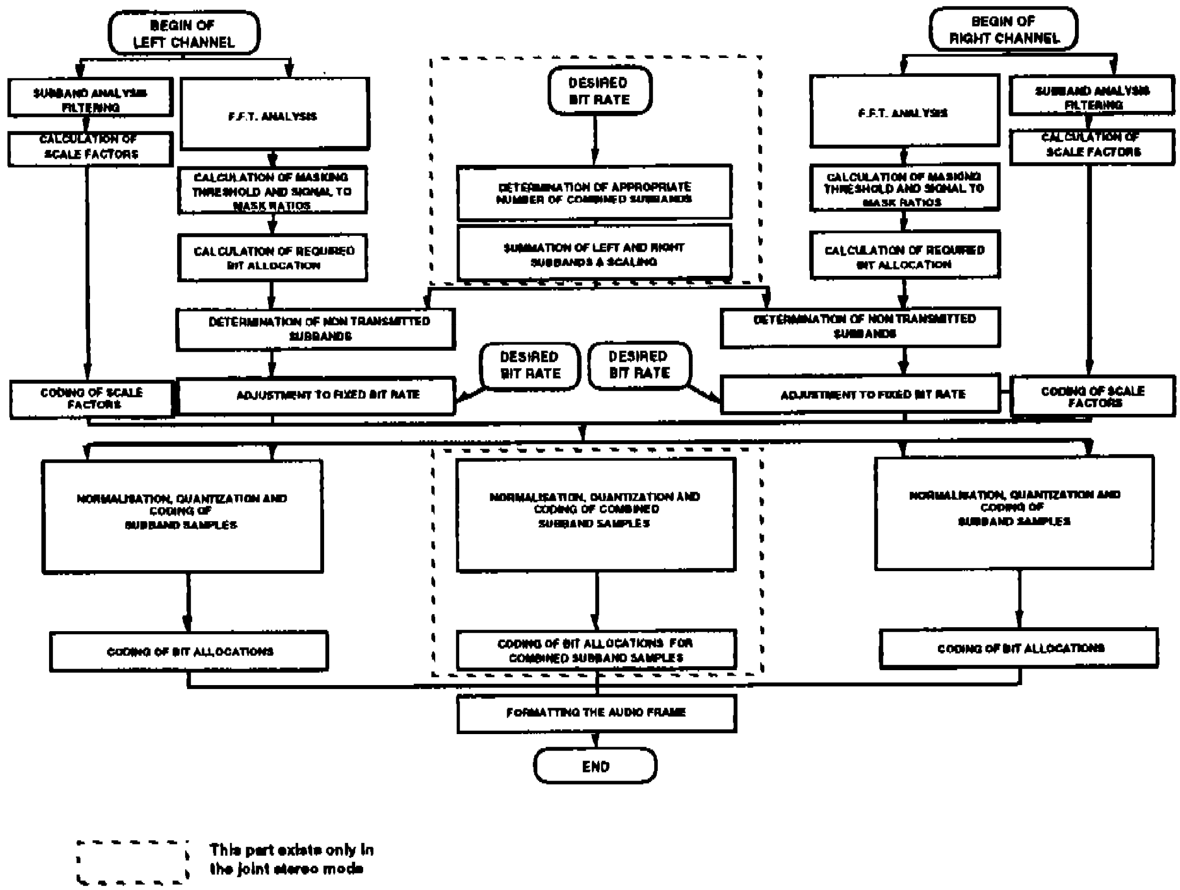

Figure G.1 -- General stereo encoder flow chart

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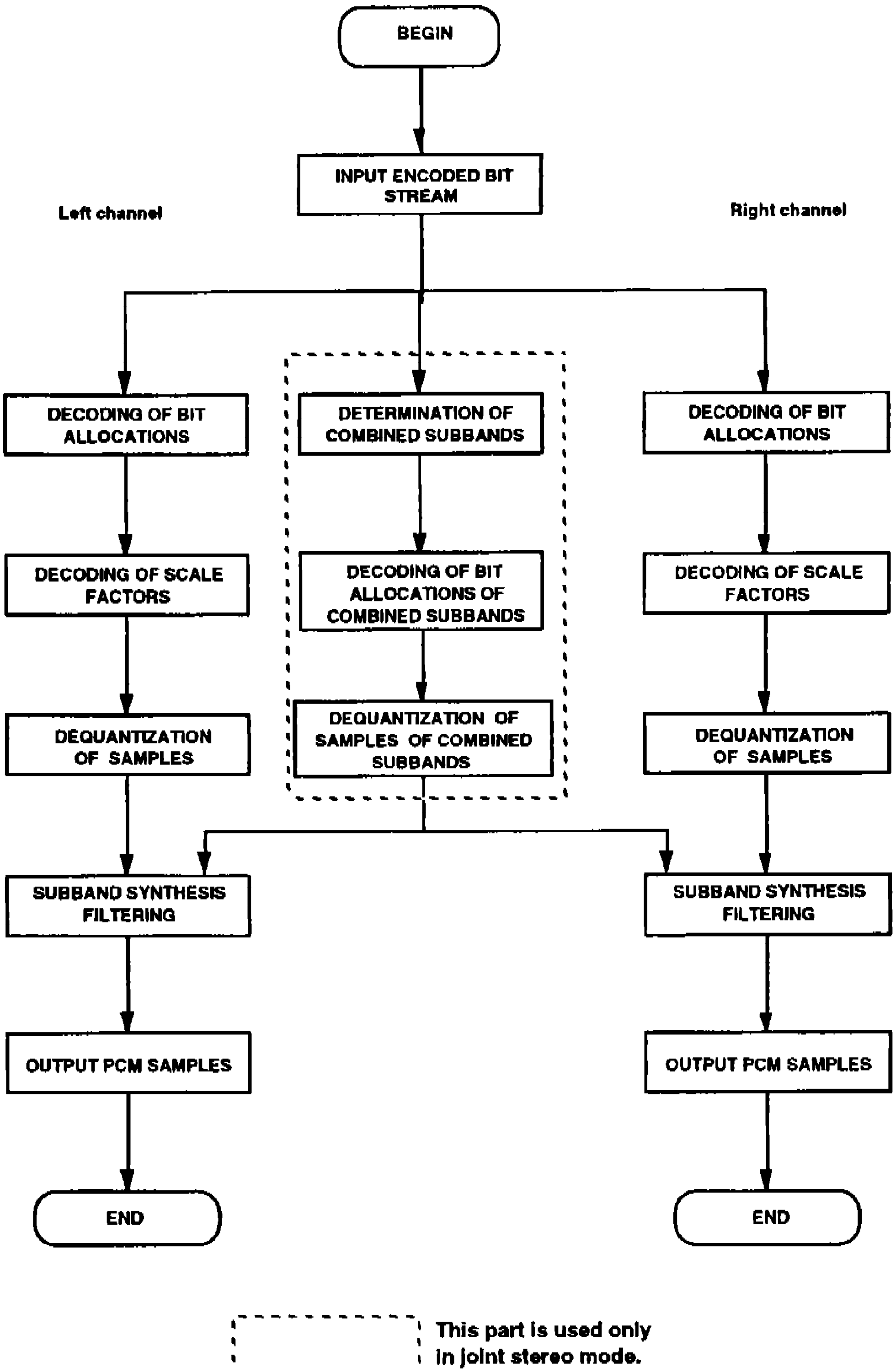

Figure G.2 -- General stereo decoder flow chart

Annex H

(informative)

List of patent holders

The user's attention is called to the possibility that - for some of the processes specified in this part of ISO/IEC 11172 - compliance with this International Standard may require use of an invention covered by patent rights.

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Bellcore
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Livingston
NJ 07039
USA

The British Broadcasting Corporation
Broadcasting House
London
W1A 1AA
United Kingdom

British Telecommunications plc
Intellectual Property Unit
13th Floor
151 Gower Street
London
WC1E 6BA
United Kingdom

CCETT
4 Rue du Clos-Courtel
BP 59
F-35512
Cesson-Sevigne Cedex
France

CNET
38-40 Rue du General Leclerc
F-92131 Issy-les-Moulineaux
France

Compression Labs, Incorporated
2860 Junction Avenue
San Jose
CA 95134
USA

CSELT
Via G Reiss Romoli 274
I-10148 Torino
Italy

CompuSonics Corporation
PO Box 61017
Palo Alto
CA 94306
USA

Daimler Benz AG
PO Box 800 230
Epplestrasse 225
D-7000 Stuttgart 80
Germany

Dornier Gmbh
An der Bundesstrasse 31
D-7990 Friedrichshafen 1
Germany

Fraunhofer Gesselschaft zur Foerderung der Angerwandten Forschung e.V.
Leonrodstrasse 54
8000 Muenchen 19
Germany

Hitachi Ltd
6 Kanda-Surugadai 4 chome
Chiyoda-ku
Tokyo 101
Japan

Institut für Rundfunktechnik Gmbh
Florianmühlstraße 60
8000 München 45
Germany

International Business Machines Corporation
Armonk
New York 10504
USA

KDD Corporation
2-3-2 Nishishinjuku
Shinjuku-ku
Tokyo
Japan

Licentia Patent-Verwaltungs-Gmbh
Theodor-Stern-Kai &
D-6000 Frankfurt 70
Germany

Massachusetts Institute of Technology
20 Ames Street
Cambridge
Massachusetts 02139
USA

Matsushita Electric Industrial Co. Ltd
1006 Oaza-Kadoma
Kadoma
Osaka 571
Japan

Mitsubishi Electric Corporation
2-3 Marunouchi
2-Chome
Chiyoda-Ku
Tokyo
100 Japan

NEC Corporation
7-1 Shiba 5-Chome
Minato-ku
Tokyo
Japan

Nippon Hoso Kyokai
2-2-1 Jin-nan
Shibuya-ku
Tokyo 150-01
Japan

Philips Electronics NV
Groenewoudseweg 1
5621 BA Eindhoven
The Netherlands

Pioneer Electronic Corporation
4-1 Meguro 1-Chome
Meguro-ku
Tokyo 153
Japan

Ricoh Co, Ltd
1-3-6 Nakamagome
Ohta-ku
Tokyo 143
Japan

Schawartz Engineering & Design
15 Buckland Court
San Carlos, CA 94070
USA

LUC 017328

Sony Corporation
6-7-35 Kitashinagawa
Shinagawa-ku
Tokyo 141
Japan

Symbionics
St John's Innovation Centre
Cowley Road
Cambridge
CB4 4WS
United Kingdom

Telefunken Fernseh und Rundfunk GmbH
Gottinger Chaussee
D-3000 Hannover 91
Germany

Thomson Consumer Electronics
9, Place des Vosges
La Défense 5
92400 Courbevoie
France

Toppan Printing Co, Ltd
1-5-1 Taito
Taito-ku
Tokyo 110
Japan

Toshiba Corporation
1-1 Shibaru 1-Chome
Minato-ku
Tokyo 105
Japan

Victor Company of Japan Ltd
12 Moriya-cho 3 chome
Kanagawa-ku
Yokohama
Kanagawa 221
Japan

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